IMPERIAL MINERAL RESOURCES BUREAU.

THE MINERAL INDUSTRY OF THE BRITISH EMPIRE

AND

FOREIGN COUNTRIES.

WAR PERIOD.

MAGNESITE.

(1913-1919.)

LONDON:
PRINTED AND PUBLISHED BY
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PREFACE.

The following digest of statistical and technical information relative to the production and consumption of Magnesite will constitute a part of the annual volume on the Mineral Resources of the British Empire and Foreign Countries.

In the first year of publication an effort has been made to fill in as far as possible the hiatus in the publication relating to mining and metallurgical statistics due to the war. Labour, health and safety statistics have been omitted owing to the difficulty involved in procuring reliable information over the war period, but in future issues such statistics will be included in respect of each year.

Use will also be made, to a much greater extent than at present, of graphical representation of statistics of production, consumption, costs and prices.

(Signed) R. A. S. REDMAYNE,
Chairman of the Governors.

June, 1920.
2, Queen Anne's Gate Buildings,
London, S.W.1.

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GENERAL.

The name magnesite, as used in English-speaking countries, refers to a rock or mineral consisting essentially of magnesium carbonate. It is analogous to limestone in chemical composition, and differs from the latter in containing magnesia instead of lime. Magnesite may be spathic and comparatively coarse in its crystallization, exhibiting cleavage as is the case with the commercially important magnesites of the province of Quebec in Canada, the State of Washington in the western United States, Austria, and Norway. When spathic the mineral may contain a considerable percentage of ferrous carbonate, as in Austrian magnesite, which is largely the variety known as breunnerite; or it may be almost free from ferrous carbonate as in the crystalline magnesites of Quebec, Washington and Norway.

More commonly magnesite is chalk-like, compact or cryptocrystalline in texture, as in the commercially important magnesites of India, Australia, Greece, Italy and California. Another variety of magnesium carbonate, hydromagnesite, is a distinct mineral species, with a chemical composition and physical properties essentially different from those of magnesite. Hydromagnesite has been of little or no value hitherto, and so far as it demands consideration it is conveniently dealt with in conjunction with magnesite, as it yields when calcined a product similar to that yielded by magnesite. The only deposits of hydromagnesite of any considerable size hitherto described are those of British Columbia and Spain.

It is worthy of note that differences of texture among magnesite rocks correspond to differences in chemical composition. Spathic magnesites usually contain more impurity than do compact magnesites. They generally occur in association with dolomite, and are therefore liable to contain much lime impurity. The admixture of this dolomite is less intimate in the coarse-textured breunnerite of Austria than it is in the closer-textured spathic magnesite of Quebec. Partly for this reason, and partly owing to the presence of ferrous carbonate in a state of intimate admixture, the dressing of breunnerite and the elimination of the dolomitic impurity is economically more feasible than in the case of spathic magnesite free from ferrous carbonate.

Compact (cryptocrystalline) magnesite frequently includes an admixture of quartz, serpentine, or sepiolite, and is therefore liable to contain silica impurity; but, except where its conditions of occurrence have allowed the infiltration of calcium carbonate, it is as a rule fairly free from lime impurity. This absence or low percentage of lime and iron renders it eminently suitable for the production of caustic magnesia used in the manufacture of oxychloride cement, refractory paint, etc.

The following generalized analyses illustrate the chemical difference among these various types of dressed raw magnesite :

	Spathic breunnerite Austria.	Spathic magnesite of Quebec, Norway and Washington.	Compact magnesite of Greece, India and California.	Hydro-magnesite Atlin, British Columbia.
	Per cent.	Per cent.	Per cent.	Per cent.
Magnesia	38–44	38–47	47	42
Lime	1–3	0–10	0–2	0–2
Iron oxide and alumina.	2–7	2	1	1
Silica	1–5	1–3	1–3	1
Carbon dioxide ...	50	49-51	50	36
Water	—	—	—	19

The material quarried in Austria and Hungary varies from pure magnesite to breunnerite, but consists predominantly of breunnerite.

The large variation in the lime percentage of spathic magnesites is due to varying amounts of dolomite. Norwegian (Snarum) magnesite contains no lime. The material marketed during the war in Washington State (U.S.A.) contained not more than about 2 per cent. of lime. Quebec magnesite (near Calumet), on the other hand, contains a considerable amount of dolomite, and ranges up to 10 per cent. or more of lime.

Compact magnesite generally contains very little lime; but much Italian and some Grecian magnesite contains above the normal percentage, due presumably to the presence of calcite, which has found access to the veins through the medium of infiltering calcareous solutions that have traversed adjacent masses of limestone.

The hydromagnesite of Atlin is powdery, and is remarkable for its low percentage of impurities.

Magnesite is utilized chiefly as a source of magnesia which is obtained from it by calcination in kilns. The magnesia is used in two forms, namely :—(1) As caustic magnesia, which is obtained by calcining at a temperature not exceeding 1,000° C, and which in conjunction with magnesium chloride is used for the manufacture of oxychloride cements; (2), as dead-burnt or sintered magnesia, which is obtained by calcining at a much higher temperature, preferably over 1,500° C, and which on account of its highly refractory character is adapted for use as a basic lining for steel and copper smelting furnaces. The bottom of the furnace is lined with granular sinter, the walls with magnesia bricks. Dead-burnt magnesia is used also in making refractory blocks, crucibles and tuyeres. Before the war most of the dead-burnt or sintered magnesia used for refractory

purposes was obtained from the ferriferous magnesite (breunnerite), of Austria-Hungary, the purer magnesites of Greece and India being used chiefly as a source of caustic magnesia for cement-making.

According to information received recently from the United States Bureau of Mines, it has been suggested that a coating of magnesia cement might be used as a protection for mine timber.

In the early days of the porcelain industry certain types of decorative porcelain were made with steatite as a flux, but these porcelains were not made for very long. In Italy there is a type of earthenware which, according to analysis, contains appreciable quantities of magnesia, and bulk for bulk this ware is rather lighter than the usual types of earthenware. Some vitreous sparking plugs contain between 15 and 20 per cent. of magnesia, which is introduced either as calcined magnesia or as steatite.*

Large amounts of caustic magnesia have been made into magnesium bisulphite for use in the manufacture of paper from wood pulp.

Another use of magnesite is in the manufacture of carbon dioxide. The magnesite of the Transvaal is used in this way, and the residual caustic magnesia is in part sintered to obtain refractory magnesia.

Magnesium sulphate for medicinal and chemical uses is in part made by treating magnesite with sulphuric acid.

WORLD'S PRODUCTION.

The world's supplies of magnesite before the war were drawn chiefly from Austria-Hungary and Greece. The exports of Austria-Hungary were of refractory or sintered magnesia for metallurgical uses, and were consumed chiefly in the United States, though considerable amounts were sent to other countries. The exports of Greece consisted chiefly of raw magnesite and lightly-calcined or caustic magnesia for use in the manufacture of oxychloride cement. The lightly-calcined magnesia of Greece was consumed largely by Germany for this purpose. The exports of Greece were continued and even increased during the war, under the control of the British and French Governments, but the material was used chiefly for metallurgical refractories. The shortage of supply in the United States due to the cutting off of the exports from Austria-Hungary was compensated for by a remarkable increase in production in the States of California and Washington, and to a smaller extent by an increased production in Canada.

---

* Dr. J. W. Mellor has kindly supplied this paragraph on the use of magnesia in porcelain and earthenware.

World's Production of Raw Magnesite (1).

(In metric tons.)(2)

	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Union of S. Africa.	403	519	569	553	709	756	929
Canada(*a*) ...	Nil.	Nil.	14,778	48,980	58,076	46,489	9,020
India ...	16,462	1,707	7,572	17,928	18,499	5,949	
Australia ...	7,220	2,056	1,729	4,121	9,588	4,203	9,772*
Austria-Hungary(*b*)	200,947	133,099	36,541	38,527	48,622		
Greece ...	118,054	136,701	159,981	199,484	162,938	39,340	
Italy ...	600	1,140	9,200	18,252	31,070	28,882	
Spain ...	958	583	1,400	2,500	800	1,700	
UnitedStates	8,740	10,248	27,676	140,630	287,512	210,168	147,005

(*a*) Including some calcined in 1915 and 1916.
(*b*) Sintered magnesia ; exports only.
* Excluding Western Australia.
(1) In addition to the countries mentioned in this table, Cyprus, Norway, Serbia, Russia, Mexico, and Venezuela, have produced magnesite. The Cyprus output in 1916 was 15 tons. Figures for Norway are not available. Russia's pre-war annual production of raw magnesite is estimated at 15,000 to 20,000 tons. Venezuela exported 6,360 and 1,700 metric tons of magnesite in 1916 and 1917 respectively.
(2) The metric, long, and short tons referred to at various places in this publication, are equivalent to 2,204 lb., 2,240 lb. and 2,000 lb. respectively.

BRITISH EMPIRE.

In the last year before the war for which we have fairly complete statistics, viz., 1913, the British Empire produced less than 4½ per cent. of the world's output of magnesite, chiefly from India and Australia, only comparatively small amounts being produced in the Union of South Africa during that year. The large demand for dead-burnt magnesia for use as a basic refractory during the war stimulated mining activity, and in the increased output that resulted therefrom Canada figured most prominently, owing to the proximity to the centres of steel production in the United States, where the shortage of dead-burnt magnesia due to the cutting off of imports from Austria was felt very keenly. India also increased its output substantially as the result of war conditions, but the output of Australia and the Union of South Africa remained almost unchanged. In the year 1918 the British Empire output of magnesite probably amounted to about 15 per cent. of the world's output.

In addition to the overseas countries mentioned below Cyprus has produced a small amount from the Akamas mine in the Paphos district. The deposit appears to be one of little importance however, and the production for 1916 amounted to only 15 tons. The Bureau is informed by Mr. H. E. Mason, whose firm used most of this 1916 output of Cyprus magnesite, that the bricks made from it were of good quality, though they contained a considerable percentage of lime ; and that an analysis of the fired

brick made from this Cyprus magnesite was reported by Dr. J. W. Mellor to give the following results :—

	Per cent.
Magnesia	87·36
Lime	7·77
Silica	2·52
Alumina	1·16
Ferric oxide	1·00
Potash	0·13
Soda	0·18
Loss on calcination	0·21

Refractory test, over cone 35, approximately 1770° C. (=3218° F.)

United Kingdom.

The United Kingdom produces no magnesite, and no deposits are known anywhere in the United Kingdom that offer the least prospect of development to meet the needs of either the metallurgical or chemical industries, so long as foreign magnesite is available at cheap rates. British requirements during the war were met by importation of magnesite from Greece and India. Before the war Austrian magnesia sinter was imported largely for use as a basic refractory, and when Austrian supplies were cut off, the deficiency had to be met by increased imports from Greece and India. The position of France closely resembled that of the United Kingdom.

One of the important results of the war was to necessitate a larger development of the home production of iron ore, and as the only ores available for supplying the needful quantity of iron and steel were in large part of the low-grade phosphatic type, this accentuated the need for basic refractories in steel production, and made it necessary to economise the use of magnesite as far as possible. With this end in view the French and British Governments controlled the supplies of magnesite used in the manufacture of basic refractories, which supplies were drawn largely from Greece.

Grecian magnesite was not used to anything like so large an extent as a source of basic refractories before the war, and was regarded as being less suitable for this purpose than an Austrian sinter, which could be supplied at a cheaper rate. Indeed the early efforts of British magnesia brick manufacturers to substitute Grecian for Austrian sinter during the war could not be described as other than unsuccessful. As they acquired more experience, however, they were able to make substantial improvements in the quality of magnesia bricks, and towards the close of the war they were confident that they would be able to produce from Grecian sinter, bricks that would defy the competition of bricks made from Austrian sinter.

Arrangements for the supply of Grecian magnesite to meet the requirements of the magnesia brick manufacturers in Great Britain were made before the termination of the war, and the Grecian producers contracted to supply large quantities to British

manufacturers for many years. Under these circumstances the British manufacturers will be able to take advantage of the experience gained during the war in the manufacture of magnesia bricks from Grecian magnesite.

The requirements of raw magnesite in the United Kingdom for 1918 were estimated by the Ministry of Munitions at about 50,000 tons. It has been estimated that the steelmakers' annual pre-war requirements were approximately 2¼ million of 9 inches by 2½ inches magnesia bricks, equivalent to 20,000 tons of raw magnesite. Of this quantity of bricks probably less than one million were made in the United Kingdom, leaving a balance of 1¼ million bricks to be imported from foreign countries to meet the needs of the manufacturers of basic steel.

The imports of magnesite, etc., for 1917 and 1918 are given by the Ministry of Munitions as equivalent to 95,045 tons and 43,672 tons respectively ("Iron and Steel Industry," by F. H. Hatch).

The annual values of the imports of "magnesite powder" are given in the official trade returns as follows:—

1913	£24,847
1914	22,036
1915	54,386
1916	76,032
1917	73,943
1918	21,024

The value of the exports of magnesite manufactures were not returned prior to 1915. For the years 1915, 1916, 1917, and 1918, they are given as £34,175, £233,604, £116,437, and £73,507, respectively.

Union of South Africa.*

Compact magnesite is found in deposits of considerable size in the Barberton district, eastern Transvaal, at various localities near the railway line between the station of Kaapmuiden and Malelane. Kaapmuiden is about 87 miles from Delagoa Bay, and 300 miles from Johannesburg.

Hall describes the magnesite as occurring in countless thin white veins traversing mottled serpentine in all directions. The veins vary in thickness from 3 to 4 feet down to mere films, but veins from 2 to 6 inches thick are by far the most common. They show a very irregular distribution in the serpentine and change their disposition from the horizontal to vertical within a few yards. The thicker veins (2 to 4 feet thick) are as a rule highly inclined.

The rock is perfectly white. It is rather soft as a rule and yields much dust when broken; but some masses are hard and can be handled without producing dust. The magnesite usually

* "The magnesite deposits of Malelane," by A. L. Hall; Transvaal Mines Dept. Rept. of the Geol. Surv. for 1906, p. 127.

"Magnesite in South Africa," by P. A. Wagner; S. Afr. Journ. Ind., 1918, vol. 1, 570.

"Annual Reports of the Government Mining Engineer, Department of Mines, Union of S. Africa."

contains patches and specks of serpentine. It is characterised by a somewhat cellular texture and there is a considerable amount of quartz present, lining the walls of the small cavities and impregnating the mass of the magnesite. Thin films of silica occur between the magnesite veins and the enclosing serpentine.

The following is an analysis of a comparatively pure picked specimen of the magnesite of specific gravity 2·95 :—

	Per cent.
Magnesia	45·27
Carbon dioxide	49·80
Silica	2·30
Ferric oxide	0·80
Moisture (110°C.)	0·16

An examination of samples of Kaapmuiden magnesite gives one the impression that on the average the percentage of silica is considerable, and well above the amount indicated in this analysis. A recently quoted analysis of a representative sample shows 5·24 per cent. of silica.

Up to the present there has been no considerable export of magnesite from South Africa, and, so far as can be judged from the deposits hitherto described, it does not seem likely that there will be under normal conditions, as these deposits appear to be of rather small dimensions and the Kaapmuiden magnesite is in parts very siliceous. There was an export of about 80 tons of crude magnesite from the Barberton district to the United States in 1915, but this was due to the temporary shortage of supplies and the exceptionally high price then offered in the United States.

According to a recent report only the Pettygrew's Nek deposit, about two miles S.S.W. of Kaapmuiden, is being quarried at present in South Africa. The average monthly output from this deposit during 1918 was about 65 tons. The magnesite is sold f.o.r. at Kaapmuiden station at £2 12s. 6d. per ton and the output is taken almost entirely by a Johannesburg firm for the manufacture of liquid carbon dioxide, which is used throughout South Africa for aerating water. The calcined magnesia is sold locally, and is taken mostly by the Union Steel Corporation of Vereeniging, who re-calcine it and use the sintered product in the manufacture of magnesia bricks. To do this they first briquette the caustic magnesia and dead-burn the briquettes. The sintered briquettes are then crushed, and the product thus obtained is made into bricks, which are burned in special kilns.

Production of Magnesite in the Union of South Africa.

Year.	Quantity. Short Tons.	Value. £.	Year.	Quantity. Short Tons.	Value. £
1913	444	1,194	1917	781	2,050
1914	572	1,451	1918	833	2,184
1915	627	1,568	1919	1,024	2,723
1916	609	1,766			

Canada.

Quebec.—Large deposits of magnesite occur and were quarried extensively during the war period near Calumet in Argenteuil County, Quebec. They were first observed in the year 1900, and have been described at length by M. E. Wilson in a memoir issued recently by the Geological Survey of Canada.* The chief localities are in the townships of Grenville and Harrington. Work was commenced on these deposits in a small way in 1907, at a locality about 12 miles from the Canadian Pacific Railway, the nearest station being Calumet.

The magnesite deposits are found cropping out in the form of ridges, which pierce the superficial sands and clays, and which may be as large as 1,000 feet long and 300 feet wide

The rocks of the Grenville district in which the magnesite occurs have suffered much crumpling and deformation. As a result of this, well-marked foliation and lenticular structure have been developed. The magnesite itself occurs in lenticular masses, and shows a banded appearance due to the streaky distribution of the serpentine it contains. The intimacy of association between the magnesite and the serpentine is shown by the manner in which such streaked masses of magnesite pass gradually into massive serpentine. Still more intimately associated with the magnesite is the mineral dolomite, which is almost invariably present in scattered irregular pieces through the magnesite. The dolomite is also present in the form of separate lenticular masses.

Some idea of the magnitude of certain of the Grenville district deposits may be gathered from the dimensions recorded for Outcrop No. 3, Lot 15, Range XI., in Grenville township. This deposit has a horizontal extent of 30,000 square feet, a proved average depth of 125 feet, and is estimated to contain 60 per cent. of magnesite. The estimated quantity of magnesite available in this particular deposit is 187,500 tons, and 71 samples of magnesite taken from the deposit show amounts of lime ranging from 5 to 15 per cent.

The Grenville magnesite is cobbed in the quarries to remove the impurities as far as this is economically possible. The colour and appearance of the material assists the quarrymen in their hand-dressing operations. The dolomite is dull-white or coarsely crystalline. Cream-white to glistening magnesite of medium to fine-grained texture contains as a rule less than 7 per cent. of lime, whereas the pure-white variety contains rather more lime, up to 11 or 12 per cent., and the grey varieties may contain still more lime. A laboratory test is stated to have shown that, after calcination, the dolomite slakes to a smooth paste and can be washed away, leaving a residue of purer magnesite.†

* Magnesite deposits of Grenville District Argenteuil County, Quebec, Memoir 98, Dept. of Mines, Canada 1917. See also the various Annual Reports on Mining Operations in Quebec.

† Summary Report of the Mines Branch, Dept. of Mines, Canada, for the year 1916.

Although dolomite is invariably present in the deposits, it has been shown by diamond-drilling and other development work that there is a large amount of magnesite containing on the average not more than from 7 to 10 per cent. of lime.

The following summary by Wilson shows the amount of magnesite and magnesite-dolomite in sight on various properties at the time he examined them :—

Property.	Magnesite with less than 12 per cent. lime.	Magnesite dolomite with more than 12 per cent. lime.
	Tons.	Tons.
Lot 13 Range I Harrington township ...	25,000	8,000
" 18 " XI Grenville " ...	15,000	6,000
" 15 " XI " " ...	418,000	186,300
" 15 " X " " ...	2,500	4,000
" 15 " IX " " ...	226,400	279,400
Totals	686,900	483,700

Further exploration in the Grenville district is likely to result in the discovery of other deposits, and a large increase in the proved reserves of magnesite. According to Wilson it is probable that extensive masses of magnesite occur beneath the superficial clay in the low-lying parts of the district.

The amount of magnesite marketed by Quebec operators during 1917 totalled 58,340 tons. This included some calcined and sintered magnesia. The total tonnage in terms of crude magnesite for that year was estimated at about 64,000 tons.

A notable feature of the Quebec magnesite industry in 1917 was the introduction of rotary kilns for sintering the magnesia at Montreal and Hull. The magnesite was ground to pass a 20-mesh screen, mixed with 5 per cent. of ground iron ore and sintered at a temperature of 2400°F. The product was found to be a very desirable refractory, and sold at $5 per ton. The Steel Company of Canada has experimented largely with Quebec magnesite in their open-hearth furnaces, and claim that, by suitable treatment, it yields results as good as those obtained by using Austrian magnesite. Good results are also obtained by using a mixture of sinter, caustic magnesia, and magnesium chloride as a plaster on the walls of the steel furnace.

British Columbia.—British Columbia has deposits of both compact magnesite and hydromagnesite. A deposit of compact magnesite of some note is that of the Bridge River district reported on recently by C. W. Drysdale, who described an outcrop 52 feet wide and 48 feet long near the south-west end of Liza Lake. The locality is about 30 miles from the Pacific Great Eastern Railway at Bridge River crossing on the Seton Lake.

More interesting, however, are the deposits of hydromagnesite near Atlin in British Columbia, which have been examined and described recently by G. A. Young.* The deposits are situated close to Atlin—one of the two chief groups of deposits is only about half a mile from Atlin wharf, the other is on the south-east border of the town site.

The hydromagnesite is pure white, rather soft, and falls to powder on drying. Some of it is very wet in the natural state, and may lose as much as 22 per cent. of water at 105° C., but most of it appears to be fairly dry, except for chemically combined water. Where saturated with water the deposits are so situated as to facilitate ready drainage. The mineral is exposed at the surface, and can be won by open quarrying without the removal of any overburden.

The largest deposit in the first group already referred to (about half a mile from Atlin wharf) covers about 18 acres, and appears to have an average thickness of 2 ft. 8 in. The deposit was sampled in two pits at different depths. One of those pits was in the south-eastern portion of the deposit at a point where the thickness was 2 ft. 2 in.; the other was in the northern part of the body at a point where the thickness was 3 ft. 6 in. The following analyses of samples collected in those two pits were made on material dried at 105° C., at which temperature the loss of water varied from 1·51 to 2·64 per cent.

—	South-eastern Pit.			Northern Pit.		
	Depth 5″	Depth 1′ 1″	Depth 1′ 11″	Depth 4″	Depth 1′ 4½″	Depth 2′ 4″
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Silica	1·86	0·90	0·54	1·22	1·96	9·22
Alumina	0·67	0·10	0·17	0·67	0·14	0·94
Ferric oxide ...	0·15	0·09	0·11	0·18	0·45	0·73
Ferrous oxide ...	0·60	0·45	0·64	0·63	0·65	0·78
Lime	2·04	0·82	0·68	1·26	1·50	6·44
Magnesia	41·13	42·35	42·19	40·56	41·93	35·23
Carbon dioxide ...	35·98	36·10	36·17	35·96	36·04	37·70
Water	18·02	18·95	19·05	19·04	17·66	8·20
Totals ...	100·45	99·76	99·55	99·52	100·33	99·24

The second group of deposits (that on the south-east border of the town site) consists of three large bodies of hydromagnesite that lie in shallow valleys depressed 30 to 75 feet below the surrounding country. The mineral in this group of deposits is much wetter than that of the first group, and analyses show losses of water up to 21·77 per cent. at 105° C. The largest of

* Summary Rept. Geol. Surv. Canada, 1915.

the three deposits varies in thickness from 1 foot to 5 feet, with an average of 3 feet. Two samples from different parts of this deposit lost respectively 1·21 to 1·18 per cent. of water at 105° C., and gave the following results on further analysis :—

	Per cent.	Per cent.
Silica	0·74	3·48
Alumina	0·35	2·85
Ferric oxide	0·15	0·56
Ferrous oxide	0·66	0·81
Lime	0·32	0·42
Magnesia	42·85	38·94
Carbon dioxide	36·35	34·31
Water	19·10	18·10
Totals	100·52	99·47

It is estimated that the two groups of deposits contain, approximately, 180,000 tons of hydromagnesite, in beds ranging from about 1 foot to 5 feet in thickness. It is reported that about 200 tons of the material was shipped to San Francisco in 1904 and that some was sent to England. During 1915 a trial shipment of some 500 tons was sent to Vancouver. The district is stated to be easily accessible by way of the White Pass and Yukon Railway from Skagway, Alaska, to Carcross, Yukon Territory, and thence by a bi-weekly boat service on Tagish and Atlin Lakes.

Another locality in British Columbia where, according to G. C. Hoffmann,* hydromagnesite occurs in considerable abundance is that near the 180 mile house in the Cariboo Road, 93 miles north of Ashcroft, in Lillooet district. At this locality there are three or four deposits from 50 to 100 feet across, standing a foot or more above the level of the surrounding surface, and the hydromagnesite is traceable from one to the other of these deposits over an area of some 50 acres of ground. A shaft sunk in one of these deposits passed successively through about 5 feet of the pure white material, a layer of about 6 inches of the same of a somewhat yellowish colour, a layer of some 3 feet of the pure white material, a layer of about 18 inches of the yellowish coloured material, an apparently thin layer of the pure white material, and finally reached what evidently constituted the bed of the deposit, viz., a dark coloured mud containing a few well-preserved shells.

On another of these deposits a shaft is stated to have been carried to a depth of 30 feet without the bottom being reached.

The material examined consisted of a pure white, somewhat compacted, yet readily friable aggregate of fine crystalline particles with a few intermingled rootlets. An analysis by R. A. A. Johnston gave :—

* **Ann. Rept. Geol. Surv. of Canada, new series, vol. 11, p. 10 R, 1898.**

	Per cent.
Magnesia	43·71
Lime	0·10
Carbon dioxide	37·03
Alumina	0·02
Ferric oxide	0·04
Phosphorus pentoxide	0·30
Soluble silica	0·38
Insoluble, chiefly silica	1·53
Water with a little organic matter	17·70

An analysis of the insoluble portion showed that of the 1·53 per cent., 1·35 consisted of silica, and 0·10 of alumina.

It is thought that the origin of these deposits is connected with the occurrence of the later Tertiary volcanic rocks, basalts, etc., which are abundant in the area referred to.

*Production of Magnesite in Canada.**

Year.	Quantity. Short Tons.	Value. $	Year.	Quantity. Short Tons.	Value. $
1913	—	—	1916	53,976 (*a*)	525,966
1914	—	—	1917	64,000	729,025 (*b*)
1915	16,285	(*a*) 137,353	1918	51,231	1,016,764 (*b*)
			1919	9,940	283,719

(*a*) Including some calcined.
(*b*) This represents the total value of the magnesite sold, including crude calcined, or sintered.

Sales of Canadian Magnesite (raw, calcined and dead-burnt).†

Year.	Quantity. Short Tons.	Value. $	Year.	Quantity. Short Tons.	Value. $
1913	515	3,335	1916	55,413	563,829
1914	358	2,240	1917	58,090	728,275
1915	14,779	126,584	1918	39,365	1,016,765

Canadian Imports of Magnesia.†

Year.	Quantity. Short Tons.	Value. $	Year.	Quantity. Short Tons.	Value. $
1913	145	12,226	1916	195	20,651
1914	127	16,429	1917	58	16,186
1915	91	9,695	1918	47	13,200

* Annual Reports on Mining Operations in the Province of Quebec.
† Annual Reports on the Mineral Production of Canada.

*Canadian Imports of Magnesia.**

(Fiscal Years ending March 31.)

Imported from	Quantity (lb.)						Value ($.)					
	1913.	1914.	1915.	1916.	1917.	1918.	1913.	1914.	1915.	1916.	1917.	1918.
United Kingdom	55,150	68,011	48,032	32,202	53,429	10,544	4,108	4,544	3,830	2,656	5,598	473
Australia	400	—	—	—	—	—	21	—	—	—	—	—
British Empire	55,550	68,011	48,032	32,202	53,429	10,544	4,129	4,544	3,830	2,656	5,598	473
France	10	—	—	—	—	—	3	—	—	—	—	—
Germany	214,353	52,400	3,345	—	—	—	1,757	1,774	416	—	—	—
Italy	3,040	4,610	—	—	—	—	283	672	—	—	—	—
Netherlands	46,946	1,320	—	—	—	—	747	55	—	—	—	—
United States	474,156	182,517	137,366	260,684	212,545	90,033	20,831	7,084	9,886	11,481	12,944	14,073
Foreign Countries	738,505	240,847	140,711	260,684	212,545	90,033	23,621	9 585	10,302	11,481	12,944	14,073
Totals	794,055	308,858	188,743	292,886	265,974	100,577	27,750	14,129	14,132	14,137	18,542	14,546

* Annual Reports of the Trade of Canada.

India.

The mining of magnesite in India has taken place chiefly in the "Chalk Hills" of the Salem district of the Madras Presidency, and only to a comparatively small extent in Mysore. The magnesite obtained has been of the Grecian type.

The "Chalk Hills" are situated some 4 or 5 miles to the north and north-west of the town of Salem, in southern India. The Madras railway runs within a mile or so of the deposits, but the distance from the port of Madras is about 200 miles. These hills received their name from the chalk-like appearance of the veins of magnesite, which stand out boldly and make a conspicuous feature on their bare surfaces. According to Middlemiss,† the hills comprise two areas of about 1¼ and 3½ square miles. The rock of the hills consists of serpentinised peridotite (olivine rock); this altered peridotite is intrusive in gneisses, which occupy the surrounding plain. The serpentine is veined irregularly with magnesite. Middlemiss estimated that magnesite constituted from a third to a half of the total volume of the rock over an area of 620,000 square yards, and about a tenth to a sixth over an area of 5,536,000 square yards. The richest portions of the deposits seen at the surface form hillocks rising to various heights, up to 140 feet above the plain, so that an almost unlimited supply is available by means of quarrying.

The following are analyses of a cargo sample and a selected specimen of Salem magnesite, as quoted by H. H. Dains* :—

	Cargo sample. Per cent.	Selected specimen. Per cent.
Magnesia	46·28	47·35
Lime	0·78	nil
Ferric oxide / Alumina	0·14	0·30
Silica	1·17	0·22
Carbon dioxide	50·10	51·44
Combined water...	1·30	0·27
	99·77	99·58

Samples of caustic and dead-burnt magnesia obtained from Salem magnesite gave the following results :—

	Caustic. Per cent.	Dead-burnt. Per cent.
Magnesia	96·10	93·12
Lime	1·03	1·04
Ferric oxide	—	—
Alumina	0·44	1·22
Silica	0·54	4·38
Loss on ignition	2·31	0·34

* Jour. Soc. Chem. Ind. 1909, 28–503.

† Rec. Geol. Surv. India 1896, vol. 29, p. 31.

According to B. H. Brough* and E. Kilburn Scott,† experiments made on a considerable scale with Salem magnesite in the electric furnace yielded a hard, dense product of high refractory quality which is suitable for the manufacture of bricks. Moreover, when powdered, and mixed with some adhesive material, it yields a paste and mortar which can be used for the protection of the brick walls of furnaces. Brough also points out that in an electric furnace, magnesia, unlike lime, does not form a carbide with carbon.

The mining and burning of Salem magnesite has been dealt with recently in a paper by C. H. Burlton.‡ He states that the quarry faces are "40 feet sheer" and that the proportion of the magnesite taken out in development may be about 15 per cent. of the "deads," which are removed on tram lines to dumps. The magnesite is hand-dressed and stacked. The lumps of magnesite obtained by quarrying vary in size from pieces known as "lump," which are double the size of a man's fist, down to pieces the size of an apple or walnut, which are known as "smalls." "Lump-crude," to which 30 per cent. of "smalls" may be added, can be used for calcination in kilns. Smalls are in demand for chemical uses.

The magnesite is railed to Madras, partly in a crude and partly in a lightly calcined (caustic) condition. It takes 24 hours to pass the magnesite through the kilns, and three hours through the zone of greatest heat, which is reckoned to range from 700° to 900° C., and does not exceed 1,000° C. The caustic magnesia is ground so that less than 3 per cent. remains on a 120-mesh sieve. To produce one ton of lightly calcined magnesia from 2.2 tons of crude magnesite requires from 0.2 to 0.3 of a ton of coal.

A portion of the caustic magnesia produced in India is further calcined to obtain dead-burnt magnesia for use as a refractory. The present active development of iron mining and metallurgy in India offers an important opening for its use on a larger scale.

No dead-burning has been done at Salem itself since the experiments which were made some years ago, and which were qualitatively but not commercially successful. In these experiments about 60 tons of magnesite was dead-burnt at a temperature of 1,700° C., but this temperature proved too high for the furnace, though it should be pointed out that in these experiments the magnesia bricks used in the furnaces were merely hand-moulded.

According to Dr. W. F. Smeeth and P. Sampat Iyengar,§ the

* Journ. Soc. Arts, 1904, vol. 52, p. 156.
† Trans. Faraday Soc., 1905, vol. 1, p. 289.
‡ Journ. East Indian Assoc., 1917, vol. 8, p. 1.
§ "Mineral Resources of Mysore," General Series, Bull. No. 7, Dept. of Mines and Geology, Mysore State, 1916.

only deposits of importance among the various occurrences known in the Mysore and Hassan districts of Mysore State are those at Dod Kanya and Dod Katur, which are situated between Mysore and Nanjangud. These are vein deposits of the normal type, in serpentine. At Dod Kanya a patch of serpentine in the Dharwar schists occupies an area about three-quarters of a mile long and quarter of a mile wide. The serpentine is traversed by veins of magnesite which vary in thickness up to several feet. The veins tend to be either horizontal or vertical, and several of the larger masses are horizontal or but slightly inclined. It is estimated that a considerable proportion of the serpentine mass would yield about a ton of magnesite for every 10 tons of rock excavated, and that the total amount of workable magnesite would amount to several hundred thousand tons.

The magnesite of Mysore is sometimes rendered impure at and near the surface by admixture with kankar (nodular calcium carbonate). This impurity disappears a few feet below the surface. Other impurities which require to be separated from the magnesite in mining operations are serpentine, amphibolite (hornblende rock), and chalcedonic silica. When freed as far as possible from these impurities the magnesite is of good quality.

The following analyses quoted from the bulletin referred to above show the composition of magnesite from the Dod Kanya deposit in the Mysore district :—

—	Impure surface samples.		Large sample from stacks.	Clean magnesite from different depths.			
				3 ft.	6 ft.	9 ft.	12 ft.
Magnesia	32·48	40·88	43·52	46·49	45·25	45·84	47·12
Lime	16·29	6·56	1·24	0·45	0·48	0·52	0·35
Ferric oxide ... / Alumina ...	0·56	0·57	1·18	0·07	0·12	0·12	0·12
Silica	2·44	—	5·64	—	—	—	—
Insoluble residue ...	—	2·82	—	1·78	3·60	2·72	0·75

On the basis of prospecting work carried out at Dod Kanya, it has been estimated that the probable cost of mining and sorting the magnesite will be from 3 to 5 rupees per ton of magnesite exclusive of supervision.

The results of an investigation of the suitability of Mysore magnesite for making dead-burnt magnesia indicated that the best procedure was to grind the magnesite with a small quantity of iron oxide to induce incipient fusion, and thus confer upon it in some measure the features possessed by Austrian dead-burnt magnesia.

*Production and Value of Raw Magnesite in India.**

Year.	Quantity. Long tons.	Value.† £	Year.	Quantity. Long tons.	Value.† £
1913 ...	16,198	14,776	1916 ...	17,640	14,065
1914 ...	1,680	557	1917 ...	18,202	14,559
1915 ...	7,450	3,973	1918 ...	5,853	4,641

* Records of the Geological Survey of India.
† Value taken as cost price at the kilns.

Australia.

Magnesite of the compact or Grecian type occurs in many different parts of Australia, and at some localities there are deposits of considerable size. The more important of these deposits are those of Fifield in New South Wales, Heathcote in Victoria, and Tumby Bay in South Australia, all of which have yielded supplies of magnesite in recent years. Promising deposits are reported to occur also in Queensland and in Western Australia.

New South Wales.—The magnesite occurring about 3½ miles north-west of Fifield in New South Wales shows at the surface as large blocks piercing a bed of red clay, and is exposed in this manner over an area of about 100 acres.* The magnesite is white and very pure. An analysis by Mingaye gave the following result :—

	Per cent.
Magnesium carbonate	99·01
Lime	absent
Ferric oxide and alumina	0·54
Silica	0·42

The deposit at Fifield appears to be of considerable extent. According to Jaquet the cost of loading into drays at the time he wrote was 1s. to 1s. 6d. per ton. Fifield is 350 miles from Sydney and 11 miles from the Bogan Gate—Bulbodney. line.

According to the New South Wales Mines Department Report for 1916 the total output of magnesite in New South Wales for that year was 3,761 tons, and of this total Fifield produced 3,516 tons. 200 tons were produced at Attunga, and 45 tons at McIntyre.

Victoria.—Magnesite has been raised in small quantities in recent years at Heathcote in Victoria. The total production of the mineral in this state up to the end of 1914 was only 510 tons valued at £1,578. The Heathcote deposits yielded 189 tons, valued at £3 per ton, in 1915.

* **Ann. Rept. Mines New South Wales for the year 1907, p. 75.**

The magnesite at Heathcote occurs superficially as nodules and veins near the junction of a basic serpentinous rock with granite. The veins occur in the granite as well as in the serpentinous rock. The latter is much decomposed at the surface, and it appears to be the result of this decomposition under weathering influences that the magnesite has been formed.

Queensland.—Magnesite veins in serpentine rocks are reported to occur at many localities in Queensland, but mostly in deposits of small extent. In a recent report on these occurrences B. Dunstan* states that the deposits about Marlborough and Kunwarara, between Rockhampton and St. Lawrence, are extensive. At Princhester Creek, in the district of central Queensland, hundreds of tons of magnesite are exposed at the surface. Outcrops of magnesite are numerous at various other localities in the same district. Deposits of pure magnesite, which appear to be of considerable extent, occur at Mt. Pring, 12 miles from the port of Bowen. The following are analyses of some of these Queensland magnesites :—

—	Mt. Pring.	Kunwarara. (a)	Kunwarara. (b)	Prin-chester.
	Per cent.	Per cent.	Per cent.	Per cent.
Magnesia	46·00	43·40	46·80	46·90
Lime	1·18	0·10	Trace	1·50
Ferric oxide } Alumina }	Nil	1·50	0·50	0·20
Silica	0·90	8·00	2·00	0·20
Carbon dioxide	51·72	46·70	50·30	51·30

South Australia.—The magnesite deposits worked near Tumby Bay in South Australia have been described recently by L. K. Ward.† They are situated in the hundred of Stokes, about 5 miles from the town of Tumby in Eyre Peninsula. Deposits of talc occur in the same district, which is occupied by ancient metamorphic rocks.

The magnesite occurs in the form of veins, which are irregularly spaced over an area of 21 by 1½ chains. The veins vary in thickness up to 4½ feet, and a few of them appear to extend continuously for a length of 40 feet. Hæmatite veins run parallel to those of the magnesite, and the magnesite is in part stained superficially with iron oxide. White specimens of the weathered magnesite are scattered over the surface of the deposit, and one of the specimens was found to contain 99·38 per cent. of magnesium carbonate. Three samples from three different trenches, representing material of average quality to be obtained

* Queens. Govt. Min. Jour., vol. 17, 1916, p. 529.
† Rev. of Min. Oper., South Australia, No. 20, 1914.

by hand-picking, were analysed by W. S. Chapman, and gave the following results :—

	No. 1 Trench.	No. 2 Trench.	No. 3 Trench.
	Per cent.	Per cent.	Per cent.
Magnesia	41·83	46·23	43·01
Carbon dioxide	46·86	50·99	47·46
Lime	1·08	0·24	0·32
Ferrous oxide	0·14	0·20	0·19
Ferric oxide	0·96	0·20	0·46
Alumina	2·03	0·57	2·13
Silica	5·56	1·00	5·12
Sodium chloride	0·28	0·11	0·18
Water at 100°C.	0·30	0·16	0·26
Water above 100°C.	0·94	0·20	0·34
Totals	99·98	99·90	99·47

A further reference to the magnesite deposits of the Tumby Bay district appeared more recently in the Rev. Min. Oper. S. Austr., No. 24, 1916, in which it was stated that 100 tons of magnesite was at the time of writing awaiting shipment from Tumby Bay jetty to Port Pirie.

Western Australia.—In Western Australia magnesite has long been known to occur at Bulong, in the north-west Coolgardie goldfield, and this occurrence has been described recently by F. R. Feldtmann.* Bulong is about 19½ miles east of Kalgoorlie. The rocks of the locality are described as a greenstone complex ; they consist chiefly of serpentine and gabbro, with occasional masses of talcose rock.

The magnesite occurs as veins in the serpentine, which is usually much decomposed in the vicinity of the veins. The veins in some places are closely crowded. The main area occupied by magnesite outcrops is over 2 miles in length, and the total area covered by the magnesite-bearing serpentine in this area alone is over 300 acres, and there are others.

Trial pits down to a depth of 12 feet from the surface showed veins of magnesite up to 2 feet thick. No estimate could be formed as to the amount of material available, but it seems clear that a large tonnage of magnesite containing over 90 per cent. of magnesium carbonate could be obtained.

* Rept. Dept. Mines, Western Australia, for the year 1915, p. 131.

*Production of Crude Magnesite in Australia.**

Year.	New South Wales.		Victoria.		South Australia.		Western Australia.		Total Commonwealth.
	Quantity. Long tons.	Value. £	Quantity. Long tons.	Value. £	Quantity. Long tons.	Value. £	Quantity. Long tons.	Value. £	Quantity. Long tons.
1913	7,000	—	104	366	—	—	—	—	7,104
1914	2,000	—	23	69	—	—	—	—	2,023
1915	830	—	189	567	80	160	602	602	1,701
1916	3,761	6,918	30	90	166	332	98	98	4,055
1917	9,189	9,992	74	222	150	300	21	21	9,434
1918	3,365	4,812	225	675	440	666	105	334	4,135
1919	9,265		77		273				

* Annual Reports of the Department of Mines, New South Wales. Annual Reports of the Secretary for Mines, Victoria. Review of Mining Operations, South Australia. Annual Reports of the Department of Mines, Western Australia.

FOREIGN COUNTRIES.

At the outset of the war period Austria and Greece had been for some years the chief producers and exporters of magnesite and magnesia sinter. The output in Greece continued to rise during the war to meet British, French and United States requirements; but the output in Austria-Hungary fell considerably, and the consumption of the Central Empires for war purposes appears to have been far less than the exports from Austria-Hungary before the war. The most remarkable feature of foreign developments during the war period, however, was a large increase in the output of the United States.

In addition to the foreign countries enumerated below, Mexico and Serbia should be mentioned. In Mexico, deposits are reported to occur in the island of Santa Margarita in Magdalene Bay, Lower California, and in the island of Cedros further north. The United States imported 81 short tons of magnesite from Mexico in 1912. In Serbia deposits occur, and have been worked at Kraljevo and other localities.

Deposits of magnesite in Manchuria, presumably of the compact vein type like that of Greece, received much attention during the period under review. They are within a few miles of the South Manchurian Railway, and are largely under Japanese control. The deposits are reported to be very large, and the magnesite of good quality. An analysis of the Manchurian magnesite gave 47·13 per cent. magnesia, 0·64 iron oxide and alumina, 1·48 silica, and 50·75 loss on ignition.

Austria and Hungary.

Austria-Hungary produced magnesia sinter before the war chiefly for export purposes, from deposits of the breunnerite type in Styria, Lower Austria and northern Hungary. The following summary of information concerning the deposits of this region is based on the accounts given by F. Foetterle,* J. Rumpf,† K. A. Redlich,‡ and F. Cornu.§

The Styrian and Lower Austrian deposits have the advantage that they are much nearer their Adriatic port than are those of northern Hungary, and it is from them that most of the Austro-Hungarian magnesite hitherto exported has been obtained. They are situated in the region to the south-west of Vienna, along a tract extending westward from Semmering through the Mürz valley to the Tyrol. The largest and most important deposit is that of Veitsch, which is situated near Mitterdorf, a station on the South Austrian railway in the Mürz valley, in Styria.

* Jahrb. k.k. geol. Reichanstalt, 1852, vol. 3, p. 145; 1855, vol. 6, p. 68.

† Tschermak's Min. Mitt., 1873, p. 263.

‡ Various papers in Zeit. f. prakt. Geol.; and Doelter's Handbuch der Mineralchemie, Band 1, p. 243.

§ Zeit. f. prakt. Geol., 1908, vol. 16, p. 449.

The Veitsch magnesite occurs as lenticular masses in a belt of foliated Carboniferous rocks consisting of metamorphosed shales, sandstone, conglomerates and limestone. The chief lenticular mass of magnesite near Veitsch forms the main part of the Sattlerkogels, a hill lying about a kilometre to the north-west of the village. The summit of the Sattlerkogels is about 3,260 feet above sea level, and nearly 1,000 feet above the level of the Veitsch works. The magnesite is quarried on the slope of the hill in a series of terraces about 50 feet apart through a vertical distance of nearly 500 feet. The magnesite lens is three-quarters of a mile in length, and over 1,000 feet in width. So far as can be judged from its disposition it probably extends to a considerable depth.

The chief minerals of the Sattlerkogels deposit, as described by Cornu, are magnesite and dolomite. The magnesite is greyish in colour when fresh, and contains sufficient ferrous carbonate to blacken when calcined in a reducing atmosphere. The amount of iron carbonate is variable, and various analyses show percentages ranging up to 13 or 14 per cent. A little pyrite is frequently present. Scaly masses and films of talc are associated with the magnesite.

Although selected specimens of the Sattlerkogels breunnerite show so much variation in the percentage of ferrous carbonate present, there is comparatively little variability in the percentage of iron oxide in the sintered product as marketed. This may be seen from five analyses of sintered magnesite quoted by Cornu, which show variation between the following limits :—

	Per cent.
Magnesia	85·53—90·07
Lime	0·96— 3·52
Ferric oxide	7·43— 9·96
Manganese oxide	0·51— 0·76
Silica	0·26— 1·34
Alumina	nil— 2·22

A. Kern* quotes the following analyses of sintered magnesite for some of the more important Austrian localities :—

—	Veitsch.	Breitenau.	Semmering.	Sunk.	Salzburg
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Magnesia	84·2	87·9	85·9	85·9	86·7
Lime	2·5	2·8	3·0	4·5	2·0
Ferric oxide ...	8·4	5·5	5·3	6·8	5·9
Alumina	—	0·7	0·1	1·4	1·1
Silica	3·8	2·0	5·1	0·6	2·2

According to Cornu, dolomite is abundant in the Veitsch magnesite deposits, partly as a fine-grained, greyish-black rock, and

* Glückauf, 1912, vol. 48, p. 281.

partly in the form of coarsely crystalline and yellowish-white masses. Large cleavage fragments of 10 to 20 cm. edge are obtainable from those masses of coarse-texture dolomite which are enclosed.

The sintering temperature varies from 1,400° C. for breunnerite containing a considerable percentage of iron oxide to 1,700° C. for magnesite poor in iron oxide; but however easily the material sinters, it is, according to Hörhager, desirable to carry the temperature up to at least 1,500° C., and this temperature seems to be exceeded as a rule in Styrian shaft kilns. Hörhager states that the amount of fuel required to sinter Austrian magnesite is variable, and depends on the amount of ferrous carbonate present; but with good flaming brown coal having a calorific value of 6,000 calories, the amount of coal required is from 0·3 to 0·4 ton per ton of sintered magnesia produced. Kern puts the fuel requirements at 0·5 ton of brown coal (calorific value 4,000 calories) per ton of sintered magnesia produced.

According to L. C. Morganroth,* kilns of the rotary type have been installed at several places in Austria, powdered coal being used as fuel, but they suffer from the disadvantage of yielding a large percentage of fines.

Sintering does not destroy the rhombohedral form of the magnesite fragments, and a microscopical examination of the powdered sinters show clearly the characteristic texture that has been described by Cornu.

The crushed sinter, as a rule, requires to be further dressed to eliminate impurities, for these are far from having been completely removed before sintering. For this purpose the grains are classified mechanically. Much of the caustic lime or calcined dolomite falls to dust and is easily eliminated in the finest screenings. The coarser grains are readily dressed by hand-picking, the light-coloured and therefore readily-distinguished impurities, such as talc, calcined dolomite and silica being easily removed in the Veitsch breunnerite. Such included lumps of dolomite are naturally regarded as objectionable by the quarrymen, and have to be eliminated as far as possible either by cobbing in the quarry or in subsequent dressing operations, as otherwise the product obtained would contain too much lime. The colour of the dolomite lumps helps the quarrymen to detect their presence. Lime is regarded as an objectionable ingredient in calcined magnesia, and efforts are made to keep its percentage as low as possible in the sintered product. Austrian sinter usually contains a variable but small percentage of lime, which is doubtless due to the presence of dolomite in the raw material.

According to J. Hörhager† and A. Kern‡ the quantity of waste rock obtainable in quarrying may amount to about two-thirds of the total bulk of the rock. The freshly quarried material

* Bull. Amer. Inst. Eng., 1914, p. 2350.
† Stahl und Eisen 1911, vol. 31, p. 955.
‡ Op. cit.

is cobbed to free it as far as possible from coarse fragments of impurity such as schist, dolomite and quartz, and the lumps are sorted. The cleaner portions of the rock are reduced to pieces about head-size. Less pure material has to be broken into smaller pieces, of fist-size, and its dressing involves a considerable loss of magnesite in the form of fragments smaller than nut-size, which are too small to be burnt in shaft kilns. The raw magnesite thus obtained in the quarries at Sattlerkogels, near Veitsch, is readily transported by aerial ropeways and shoots to the sintering kilns at the foot of the hill.

The less coarse material is presumably in large part marketed in a comparatively impure condition, or otherwise requires to be treated magnetically to remove the impurities which are non-magnetic. This magnetic treatment, which involves much waste, adds considerably to the cost of the material, and is presumably only carried out when it is necessary to concentrate the sintered magnesia, and thus secure a more refractory product.

In addition to the sintering and dressing plant near Veitsch there are works at other localities in Styria, including those at Breitenau and Trieben. There are also works at Eichberg near Gloggnitz, in Lower Austria.

At Veitsch, transportation of the refined sinter from the kilns to the goods depot at Wartberg station is by an aerial ropeway over four miles long. The works at Breitenau are situated at the foot of the Hochlantsch (5,700 feet), where terrace-quarrying and other working conditions closely resemble those at Veitsch and Eichberg. The Trieben works are near the station at Trieben, and are some three miles from the deposits at Sunk, where the magnesite is quarried. The deposit at Radenthein has been worked since 1908 by American capital. From that date down to 1915 large quantities of sinter were shipped to Philadelphia, New Orleans and New York, and smaller quantities to Great Britain.

The overseas exports of sintered magnesia from all these works in Styria and other parts of Austria were shipped at the port of Trieste chiefly to the United States, which was the chief consumer of Austrian sinter before the war.

The Austrian magnesite formation stretches eastward beyond Vienna into northern Hungary, where large magnesite deposits are quarried between Jolsva and Nyustya in the Gömör district. Those northern Hungarian deposits have much in common with the Austrian, and in spite of their great distance inland from the Adriatic there have been considerable oversea exports in pre-war days from Fiume, to which port they were railed some 380 miles for shipment to various parts of Europe and America.

There are numerous occurrences of breunnerite in the form of scattered small crystals in talc-schists in various other parts of Austria, but such occurrences cannot be economically worked. Only the massive deposits of the Veitsch type can be quarried and worked at a profit, and even some of these are unable to

compete with the largest and most favourably situated deposits, which are easily quarried and are within easy reach of transport facilities. A factor of much economic importance in the magnesite industry of Austria-Hungary is the abundance and accessibility of brown coal which is used in the sintering kilns.

Austro-Hungarian Imports of Raw Magnesite and Sintered Magnesia.

Year.	Raw Magnesite. Metric tons.	Sintered Magnesia. Metric tons.
1913	316·5	99
1914	269·1	88·8
1915	139·2	56·1
1916	40·7	5·5
1917	18·5	1·3
1918		

Austro-Hungarian Exports of Raw Magnesite and Sintered Magnesia.

Year.	Raw Magnesite. Metric tons.	Sintered Magnesia. Metric tons.
1913	450	200,947
1914	143	133,099
1915	1,578	36,541
1916	865	38,527
1917	4,677	48,622
1918		

Comparative Table Showing the Exports of Sintered Magnesia from Austria-Hungary in 1913 *and* 1917.

Consigned to	1913.		1917.	
	Quantity. Metric tons.	Per cent.	Quantity. Metric tons.	Per cent.
United States... ...	113,300	56	—	—
Great Britain... ...	34,400	17	—	—
Germany	27,662	14·5	46,692	96
France...	14,697	7	—	—
Other Countries ...	10,888	5·5	1,930	4
Total	200,947	100	48,622	100

Greece.*

Previous to the war Greece supplied the major portion of the world's requirements of the chalk-like variety of magnesite,

* This account is based largely on information kindly supplied by the Anglo-Greek Magnesite Company.

which, on account of its low percentage of iron oxide, was used chiefly in the manufacture of magnesia cement, and Germany was the chief consumer. Most of the deposits so far exploited in Greece lie in the northern part of the island of Eubœa, where there is a belt of serpentine 6 to 9 miles in width and 15 miles in length. The magnesite occurs as white, compact masses in the form of veins, lenticles, or irregular masses in the serpentine. The dimensions of the magnesite bodies are very variable. The width of the bodies varies from 6½ feet up to 130 feet, and the greatest length so far observed in a vein is 500 feet.

The greatest depths at which deposits are worked to-day in Eubœa is about 660 feet, which depth has been reached in the Mantudi mine on the north-east coast of the island. The average depth of mining operations elsewhere does not exceed 200 feet. The veins probably do not extend to any great depth.

The more important of the Eubœa magnesite deposits may be classed in three groups, as follows :—

(1) The Limni-Galataki group, situated on the southern side of the serpentine belt. These include the Limni community mine and the deposits of the Galataki concession.

The distance of the Galataki concession to the loading port is 9 miles by railway (2 feet gauge) and 4 miles by rope line. The rope line is worked on the double rope system, and is capable of conveying 200 tons of mineral per working day of ten hours.

(2) The Mantudi-Pyli group, situated on the north-eastern coast of the island. The port of shipment for the Mantudi concession is Kymassi, which is connected with the mines by means of a 2-feet gauge railway 2½ miles in length. A rope line connects the two outlying concessions of Plakaries and Yerorevma with Mantudi.

The port of shipment for the Haghia Triti, Maccas and Stavros mines is Pyli, which is connected with the mines by a rope line capable of transporting 100 tons per working day of ten hours. This rope line is 3¾ miles long, with an intermediate station at Maccas and Stavros, nearly 2 miles from Pyli Bay.

(3) The Chalcis group, situated east-south-east of Chalcis, including the Afrati, Gerakari and Phylla mines. The transport of the magnesite mined in the Afrati district is by carts to the loading port of Lefkandi, in the Euripo channel.

The Eubœan deposits were formerly worked open-cast, but in recent years underground mining has been resorted to. In the first instance the method adopted was to work the veins by wide stalls, pillars being left to support the roof, but this has more recently given place to the long-wall method of working.

The crude magnesite obtained by mining is hand-dressed by girls, as much serpentine and calcite as possible being eliminated in this way. The hand-dressed raw material is then transported, as already indicated, to the ports of shipment, where part of it is calcined. The material to be calcined is, however, still further

dressed and broken into lumps of convenient size before it is fed into the kilns. The material is shipped partly in the raw and partly in the calcined state.

A considerable amount of magnesite has been mined in recent years in Macedonia on the Chalcidice peninsula, chiefly at Yerakino.

The following analyses show the chemical composition of typical samples of Grecian raw magnesite :—

	Typical Raw Grecian.	Mantudi. (a)	Mantudi. (b)	Macedon.	Kymi.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Magnesium carbonate	95·70	98·08	97·45	94·10 to 98·70	92·05
Calcium carbonate...	2·20	0·80	1·39	Trace to 3·00	6·15
Silica	1·48	0·30	0·20	0·16 to 4·00	1·30
Ferric oxide and alumina	0·60	1·20	1·15	0·02 to 0·40	0·50

The kilns used in Greece are large gas-fired shaft kilns, and up to a few years ago these were all of the Schmatolla type. In recent years various improvements, including Morgan gas generators, Steiger kilns, and pressure and exhaust fans, have been introduced, the result being to increase the rate of calcination and reduce the consumption of fuel. Experiments made with the rotary kiln of the Fellner and Ziegler type did not meet with great success.

The following analyses show the chemical composition of typical samples of caustic and dead-burnt magnesia obtained by calcination :—

	Caustic. Per cent.	Dead-burnt. Per cent.
Magnesia	91·00	90·62
Lime	2·50	4·10
Ferric oxide and alumina ...	2·85	1·57
Silica	2·55	3·00
Moisture	1·10	0·71

The production of caustic magnesia requires, on the average, 4·8 cwts. of coal per ton of caustic magnesia produced ; whilst in the old type of bottle kiln, dead-burning or sintering requires from 6 to 7 cwts. per ton of sintered magnesia produced. The latest type of sintering kiln requires about 4·6 cwts. per ton of sintered magnesia produced.

The coal used is in part imported ; but the lignite of Eubœa is of good quality and is used to a considerable extent in the calcination of magnesite.

*Production and Sales of Magnesite in Greece.**

Year.	Raw Magnesite.			Calcined Magnesite.			Dead-burnt Magnesite.		
	Production.	Sales.		Production.	Sales.		Production.	Sales.	
		Quantity.	Value.		Quantity.	Value.		Quantity.	Value.
	Metric tons.	Metric tons.	Francs.	Metric tons.	Metric tons.	Francs.	Metric tons.	Metric tons.	Francs.
1913	118,054	23,493	497,300	39,009	36,274	2,716,553	1,963	1,852	149,115
1914	136,701	54,631	1,228,319	25,219	26,317	2,132,575	3,344	2,616	222,079
1915	159,981	102,151	3,023,095	23,130	20,308	2,274,297	4,118	3,776	448,162
1916	199,484	162,388	5,369,793(a)	21,326	22,943	3,632,876	8,606	7,782	1,311,467
1917	162,938	94,934	4,179,015	4,287	6,047	933,932	9,820	11,062	2,280,064
1918	39,340	40,980	1,888,673	426	431	83,517	4,003	3,618	1,055,168

So far as can be ascertained the production of magnesite bricks has been as follows during the years under review :—

Year.	Production.	Sales.	
		Quantity.	Value.
	Metric tons.	Metric tons.	Francs.
1914	493	158	34,654
1915	161	164	37,980
1916	—	102	19,935
1917	—	—	—
1918			

* Tableaux Statistiques du Mouvement Minier de la Grèce.
(a) Value of 145,538 tons only.

Italy.*

In Italy compact magnesite occurs and is, or has been, quarried at Castiglioncello, at Monterufoli, and also on the island of Elba, all in the Firenze mining district, which includes the provinces of Pisa and Livorno. It is also mined to a small extent in the province of Turin.

In Elba the magnesite is quarried in a primitive manner on the slope of the Monte Capanne, in the commune of Campa, where it occurs in altered serpentine. The mineral is dug from small holes in the ground, and the holes are abandoned at a depth of a few metres. The magnesite is white, friable, rich in silica, and becomes pasty when wetted. Analyses show from 41 to 42 per cent. magnesia, about 44 carbon-dioxide, 1 to 3½ of lime, 8 to 9 of silica, and 3 to 4 per cent. of water. The output has been irregular. The recent production has been at the rate of 600 tons a year, and the magnesite is sold, at about £1 12s. per ton, for use in pottery manufacture.

The Castiglioncello deposits are in the commune of Rosignano Marittimo, on the hills between the Salvetti-Vada and Livorna-Vada railways, and within a mile of the latter. They consist of large veins in serpentine and occur near the contact of the latter with Eocene beds. Three veins running for a length of a kilometre are exposed and vary in thickness from 3 to 10 metres. Large quarries were opened up in 1914-15, and kilns for calcining the magnesite have been erected recently. Local transportation to the kiln is by light railway and rope-line. The deposits are large, and, though the output during 1915 was only from 3,000 to 4,000 tons, it is estimated that a daily output of 100 tons can be maintained.

The Castiglioncello magnesite is partly hard and compact and partly friable. Its composition when dressed is, approximately, as follows:

	Per cent.
Magnesium carbonate	89
Calcium carbonate	5
Ferric oxide	2
Silica	3

Magnesia bricks are made from the calcined product at Vada by a firm which previous to the war used material imported from Greece and Austria.

The deposit at Monterufoli, in the province of Pisa, is a vein ranging from 4 to 8 metres in thickness. It is found along with serpentine and occurs near the contact of this with Eocene beds, which include chalk. The magnesite is associated with quartz and chalcedony, which are removed as far as possible by hand-

* Rivista del Servizio Minerario.

dressing. A sample of the dressed raw magnesite gave the following analysis :—

	Per cent.
Magnesium carbonate	86·02
Calcium carbonate	9·60
Iron oxide and alumina	2·63
Insoluble	1·07

The dressed, raw magnesite is carted about 2½ kilometres to the station at Monterufoli. From there it is taken by rail to Ardenza, and thence by cart to Montenero (Livorno), where it is calcined in a Dietzsch furnace.

Production of Raw Magnesite in Italy.

(In metric tons and £.)*

Province.	1913.	1914.	1915.	1916.	1917.	1918.
Torino	600	740	2,300	1,260	1,264	
Livorno	—	400	600	600	800	
Pisa	—	—	6,300	16,392	29,006	
Total (metric tons)	600	1,140	9,200	18,252	31,070	28,882
Total Value £	320	827	12,355	21,117	39,163	67,127

Norway.

A deposit of white spathic magnesite fairly free from ferrous carbonate occurs and is worked at Snarum, in the Modum district of southern Norway. The locality where it is obtained is about 35 miles from Drammen, and is conveniently situated for shipment either at the latter port or at Christiania. The magnesite is found as veins averaging 13 feet thick in a mass of serpentine which is associated with schists and quartzites. The magnesite contains serpentine impurity, which is used in admixture with the magnesite for sintering and brick-making, as in the case of Grecian magnesite. There is a brick-making plant at the mines, and the bricks are stated to be superior to Austrian bricks in their refractory qualities. A characteristic feature of the Snarum magnesite is the absence of lime. The following are analyses of the magnesite of Snarum and a brick made from it :—

	Magnesite, Sp. gr. 3·02. Per cent.	Magnesia brick. Per cent.
Magnesia	47·29	83·6
Silica	—	9·3
Alumina	—	2·0
Ferric oxide	0·79	4·6
Carbon dioxide	51·45	—

* Converted into £ sterling at the rate of 25 lire = £1.

Russia.

Magnesite occurs and has been quarried extensively at Mt. Boltscheja, between Satka and Berdjausch, some miles to the west of Zlatoust, Ufa province, in the Southern Urals. The magnesite is reported by H. Mohr to be remarkably similar to Austrian magnesite. It consists of breunnerite, and is regarded as identical with the breunnerite of Veitsch and other parts of Styria, both in its nature and mode of occurrence.

No definite production statistics are available, but the pre-war annual output of raw magnesite from these deposits is estimated at from 16,000 to 20,000 tons. The magnesite is sintered at Satka, where there was an annual output of 400,000 bricks for some years before the war.

Spain.

Small outputs of magnesite have been reported for some years in Spain, chiefly from the Santander Province (see world's production table on p. 7). Typical compact magnesite occurs in the form of a vein 3 metres thick at La Papa, in Almeria, but this does not appear to have yielded much. The outputs reported in the past appear to have been obtained chiefly from the Esperanza and San Jose deposits of the Reinosa district, Santander Province, but neither of these consists of ordinary magnesite. The Esperanza rock appears to consist largely of dolomite, and much of the material hitherto quarried in the Santander Province seems to have been of the nature of dolomite and dolomitic limestone rather than magnesite The published analyses of the San Jose material indicate that the free magnesium carbonate is hydromagnesite, and not ordinary magnesite. The "magnesite" of Santander Province has been stated to consist of breunnerite resembling the ferriferous magnesite of Austria, but the report by E. Dupuy de Lôme and C. F. Maquieira de Borbon (Los yacimientos de carbonato de magnesia en España, Bol. Inst. Geol. España, 1918, **19**, 255) indicates that the free magnesium carbonate hitherto produced from the Santander deposits has consisted of impure hydromagnesite and not breunnerite.

The known deposits of magnesite in Spain are not large, and the material produced appears to be of rather poor quality. So far as can be judged from information at present available, Spain is not likely to become an important producer, at any rate for export purposes.

United States.

The magnesite mined in the United States before the war was entirely of the compact (Grecian) variety, and California was responsible for practically the whole of the production, which

showed no striking growth up to 1914; but the output increased largely during the war period, partly owing to the extensive development of the deposits of crystalline magnesite in Washington State, as shown by the following figures of output by States :—

United States Output of Magnesite (by States).

(Short tons.)

State.	1913.	1914.	1915.	1916.	1917.	1918.	1919.*
California ...	9,632	11,293	30,499	154,259	211,663	84,077	42,000
Washington ...	—	—	—	715	105,175	147,528	120,000

* Preliminary figures.

Previous to the war the United States was the chief consumer of Austrian magnesia sinter, which was used as a refractory in the metallurgical industries of the eastern and middle-west States, Crude Grecian magnesite was also imported in large amounts, and the imports of crude Grecian alone exceeded the total production of the United States. The shutting off of imports from Austria during 1915 and 1916 led to a serious shortage of supplies, but the loss was made good by a large increase in the Californian output, and rapid development of the spathic magnesite deposits of Washington State, together with increased imports from Canada and Greece.

The United States production declined somewhat in 1918, due to increased cost of transport and a large increase in the imports of Canadian sinter, which could be landed in the eastern United States at a cheaper rate than the Californian product.

The magnesite deposits of California occur on the western side of the Sierra Nevada, in the Tulare and Kern Counties, and at many localities in the serpentine belt of the coast range extending from the southern margin of Mendocino County to Winchester in Riverside County. The more important of the deposits hitherto worked are those of the Tulare, Sonoma, Santa Clara, and Kern Counties. It is estimated by the Geological Survey authorities that about half of the United States output in 1916 was produced by Tulare County alone, chiefly from the deposits of the Porterville district. The Porterville deposits include many veins, some of which are of large size. One of these is described as attaining a thickness of 8 feet, and as having been exploited over a distance of 785 feet of the outcrop, the actual extent of which appeared to be much greater.

The following are two analyses of samples taken from the bunker or stock pile of magnesite from the White Rock mine,

Pope Valley, in Napa County, and from Porterville, in Tulare County :—

	White Rock Mine.	Porterville Magnesite.
	Per cent.	Per cent.
Silica	2·43	0·80
Ferrous oxide	2·40	0·20
Lime	1·57	1·02
Magnesia	43·62	45·94
Carbon dioxide	50·11	51·30
	100·13	99·26

The magnesite from the White Rock mine in Napa County shows rather more iron oxide than is usually present in Californian magnesite, and on this account it was used largely during the war for the manufacture of refractory magnesia. The magnesite of the Porterville district is typical of most Californian magnesite. The company working the Porterville deposits has in the past used the calcined magnesia chiefly in the manufacture of wood pulp at its Oregon mills.

The deposits of crystalline magnesite that were opened up during the war in Washington State are situated about 60 miles north of Spokane, in Stevens County. The magnesite of this area is described as resembling marble or dolomite in texture. It occurs in thick and extensive beds which can be quarried easily and cheaply. The deposits are thus compared with those of Quebec, and, like the latter, were formerly quarried for use as marble. Several large quarries have been opened up in Stevens County, and some of these are within about 5 miles of the Chewelah railway station.

As described by R. W. Stone, the deposits of Washington State appear to be of large size. One lens of magnesite in which two quarries have been opened near Brown's Lake has a length of 1,000 ft., a thickness of 200 ft., and is worked on a quarry face 75 feet in height. The magnesite is underlain by slate, overlain by quartzite, and is associated with a compact igneous greenstone.

At the Keystone quarry, where magnesite was formerly quarried as marble, magnesite occurs mixed with dolomite in a large lens in which it is estimated that there is 1,000,000 tons of magnesite in sight.

Another, known as the red marble deposit, on account of its colour, though it contains very little iron oxide, is a lens about a quarter of a mile long and from 200 to 300 feet thick, associated with quartzite, slate, schist, and igneous greenstone. It is estimated that this deposit may contain not less than 2,000,000 tons of magnesite within 50 feet of the surface, assuming that 50 per cent. of the rock is magnesite.

Stone states that Washington magnesite commonly contains from 42 to 45 per cent. of magnesia and 1 to 2 per cent. of ferric

oxide. The magnesite sold in the raw state is specified as containing not more than 3 per cent. of silica and 2 per cent. of lime.

In 1917 the raw and calcined magnesite were delivered on the railway at Chewelah (Wash.) for $7·5 per ton and $32·5 per ton, respectively.

The activity of war developments in these Washington quarries may be judged from the fact that the output, which was only 715 tons in 1916, reached about 100,000 tons in 1917, and is expected to exceed this in 1918. During the war the magnesite was transported largely to Chicago and the eastern States for use in steel and copper furnace linings and had to bear a freight charge of $10 or more per ton.

Analyses of the samples taken from the bunker or stock pile of the magnesite produced at the quarries near Valley and Chewelah in Stevens County, Washington, are given below. One was a red magnesite from the Red Marble quarry at Valley, Washington. The other was a white magnesite from the Allen quarry at Valley, Washington. The following are the analyses which are remarkable as showing that a sample of the red magnesite which might be expected to contain an appreciable percentage of iron oxide, contains very little, and indeed rather less than that of the white magnesite :—

	Red Magnesite. Red Marble Quarry. Per cent.	*White Magnesite. Allen Quarry.* Per cent.
Silica	4·27	0·46
Ferrous oxide... ...	0·78	1·01
Lime	1·07	0·31
Magnesia	45·02	46·23
Carbon dioxide ...	49·51	50·32
	100·65	98·33

It will be observed that these analyses show very little lime in comparison with those of Quebec magnesite which they otherwise closely resemble.

*Production of Raw Magnesite in the United States.**

Year.	Quantity. Short Tons.	Value. $	Year.	Quantity. Short Tons.	Value. $
1913 ...	9,632	77,056	1916 ...	154,974	1,393,693
1914 ...	11,293	124,223	1917 ...	316,838	2,899,818
1915 ...	30,499	274,491	1918 ...	231,605	1,812,601

* Annual Reports on the Mineral Resources of the United States.

*United States Imports of Magnesite Calcined, not Purified.**

(In short tons.)

Country.	Fiscal Years ending 30th June.					
	1913.	1914.	1915.	1916.	1917.	1918.
Austria-Hungary ...	163,715	134,260	52,086	—	—	—
Belgium	—	11	—	—	—	—
Denmark	—	58	103	—	—	—
Germany	2,412	2,578	723	12	—	—
Greece	1,605	3,232	4,437	11,413	1,792	—
Italy	—	—	709	—	—	—
Netherlands	4,508	4,191	3,554	1,949	—	—
Norway	—	—	—	23	—	11
United Kingdom ...	1	13	280	349	785	932
Canada	350	404	948	2,440	2,148	10,805
Mexico	—	—	—	—	—	—
Venezuela	—	—	508	—	—	—
British East Indies ...	—	—	—	—	—	—
British South Africa ...	—	—	—	—	—	2
Total	172,591	144,747	63,348	16,186	4,725	11,750

* Foreign and Domestic Commerce of the United States.

United States Imports of Raw and Calcined Magnesite for Consumption.

Year.	Raw. Short Tons.	Calcined. Short Tons.	Year.	Raw. Short Tons.	Calcined. Short Tons.
1913... ...	13,240	167,094	1917... ...	30,277	3,966
1914... ...	13,354	121,817	1918... ...	5,432	19,049
1915... ...	49,764	26,574	1919... ...	6,381	9,471
1916... ...	75,345	9,270			

United States Imports of Magnesium Salts.

(In pounds and dollars.)

Year.	Calcined Magnesia (medical).		Carbonate of Magnesia (medical).		Sulphate of Magnesia (Epsom Salts).	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1913 ...	54,915	10,034	70,823	4,880	8,121,677	32,884
1914 ...	159,547	19,342	46,183	2,527	13,826,899	53,768
1915 ...	94,309	10,451	48,817	2,757	3,560,701	16,050
1916 ...	54,981	14,659	8,202	1,048	674,594	4,036
1917* ...	12,165	4,483	5,681	1,896	48,540	915
1918 ...	423	312	—	—	2,045	196

* For fiscal year ending June 30, 1918.

Venezuela.

Compact magnesite occurs in the island of Margarita, near the northern coast of Venezuela. The chief deposits are reported to be about a mile from the Port of Porlamar, and three miles from the port of Pambatar, both of which have good shipping facilities. American companies were reported to be working these deposits in 1912, and 508 short tons were imported by the United States from Venezuela during 1915. An output of 2,360 tons of magnesite is reported for 1917, and 600 tons for 1918. The shipments during 1917 amounted to 1,000 tons, but none was exported during 1918 owing to lack of shipping facilities.

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APPENDIX.

NOTE ON MAGNESIUM CHLORIDE.

Magnesium chloride is used chiefly in the manufacture of Sorel or oxychloride cement, which consists of a mixture of powdered magnesia and magnesium chloride. These two compounds have the property of setting to form a strong resilient cement when mixed, and in consequence of its resiliency this cement is used extensively in building construction on account of its superior quality for flooring and various other purposes. Germany was the chief consumer of Grecian caustic magnesia before the war, and it was mostly for this particular use in building construction that the Germans employed it.

Other important uses of magnesium chloride include the production of metallic magnesium, which is obtained chiefly by the electrolysis of the fused chloride, and its use in the textile trades for dressing cotton thread.

Magnesium chloride can be made from magnesite and hydrochloric acid, and it is reported to be obtained in this way in the United States; but commercial supplies in Germany are obtained as a by-product in the Stassfurt potash industry. Magnesium chloride occurs in the potash deposits and is recovered from the brines. Since it is obtained as a by-product, the winning of it has an important bearing on the successful prosecution of the potash industry, as is fully realized in Germany.

Probably all the potash salt deposits of the Stassfurt type are capable of yielding magnesium chloride as a by-product. If so, the deposits of Alsace may be expected to yield commercial supplies, as also may those of Catalonia in Spain.

According to recent reports, magnesium chloride occurs in the potash salts of Mt. Dellol in Abyssinia. At this place there is a hot spring, the water of which is saturated with magnesium chloride.

The lake brines of many localities contain magnesium chloride. The salts from the salt lake of Utah, for instance, contain about 11 per cent. of this ingredient.

From the British point of view it is worthy of note that India claims to be able to supply large quantities of magnesium chloride from Indian bitterns. The annual output of magnesium chloride at Stassfurt in Germany is stated to be 12,000 tons, and it is estimated that 193,000 tons of magnesium chloride is wasted annually from Indian bitterns.